Smart Grid Development Issues for Terrestrial and Space Applications

Technical Panel
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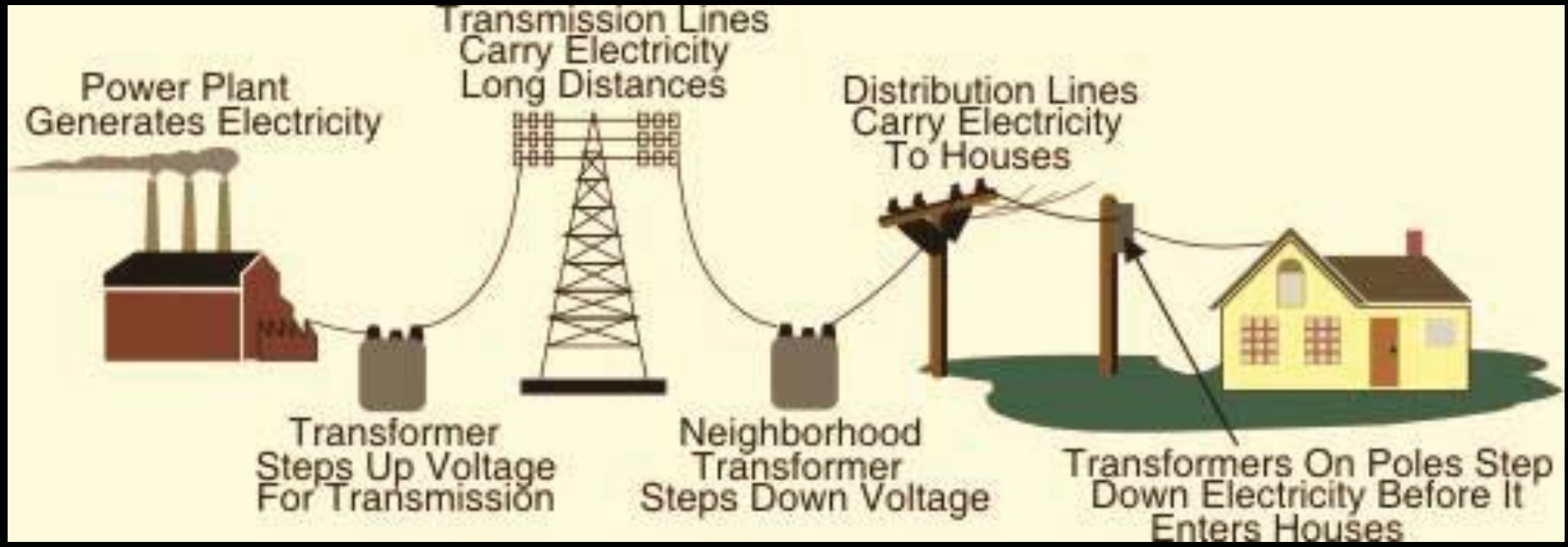
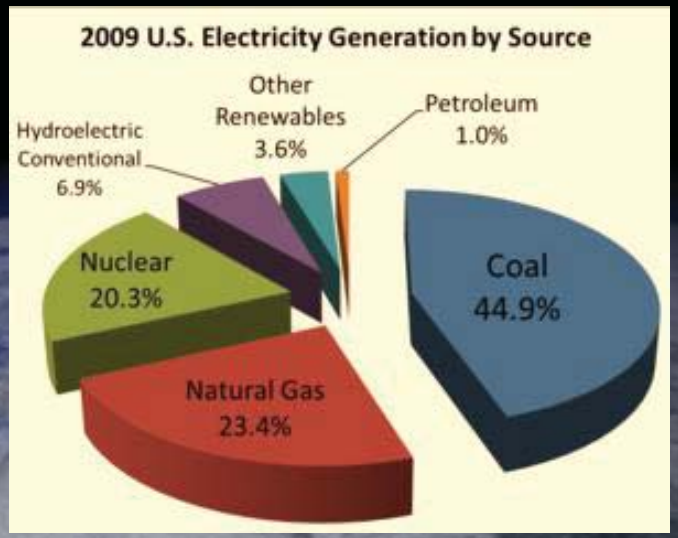
Discussion Topics

- What is the “Smart Grid”
- Smart Grid Vision
- What is NASA’s Interest in Smart Grid?
- Technology Development Needs
- Wrap Up

Traditional Terrestrial Power Systems

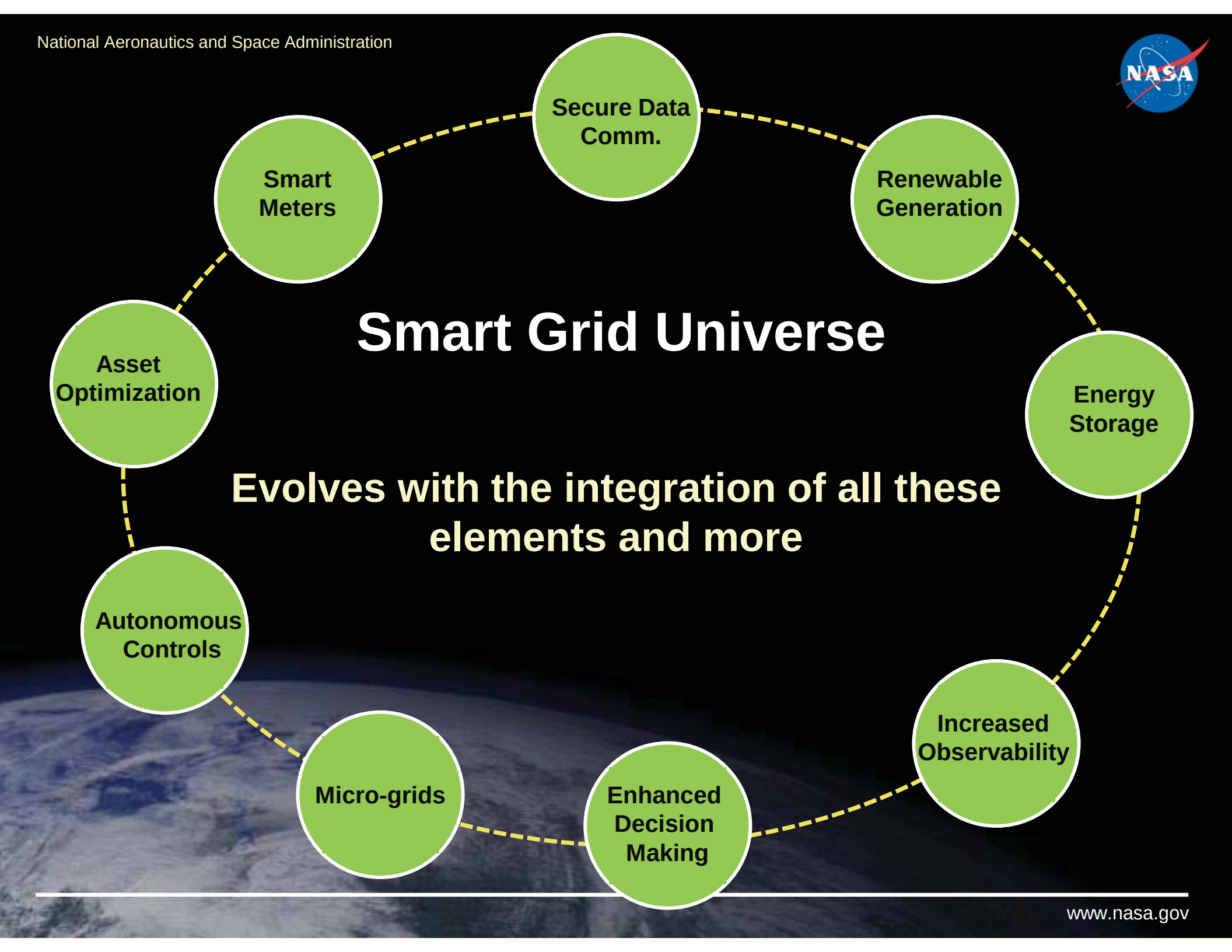




What is the Smart Grid?

- Secure Data Comm.
- Renewable Generation
- Energy Storage
- Asset Optimization
- Autonomous Controls
- Smart Meters
- Enhanced Decision Making Tools
- Increased Observability
- Micro-grids

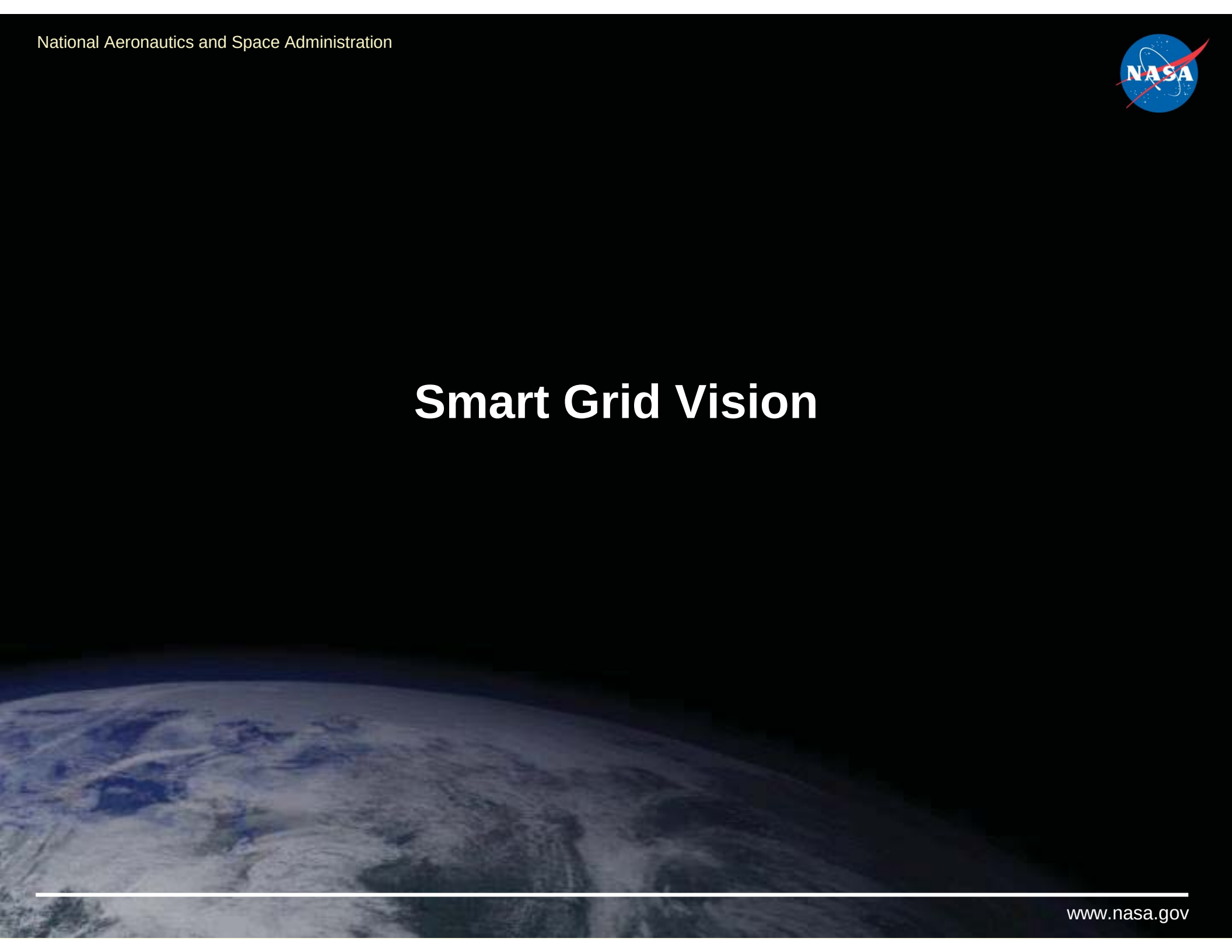
Blind Men Describing the Elephant



Smart Grid Universe

Evolves with the integration of all these elements and more

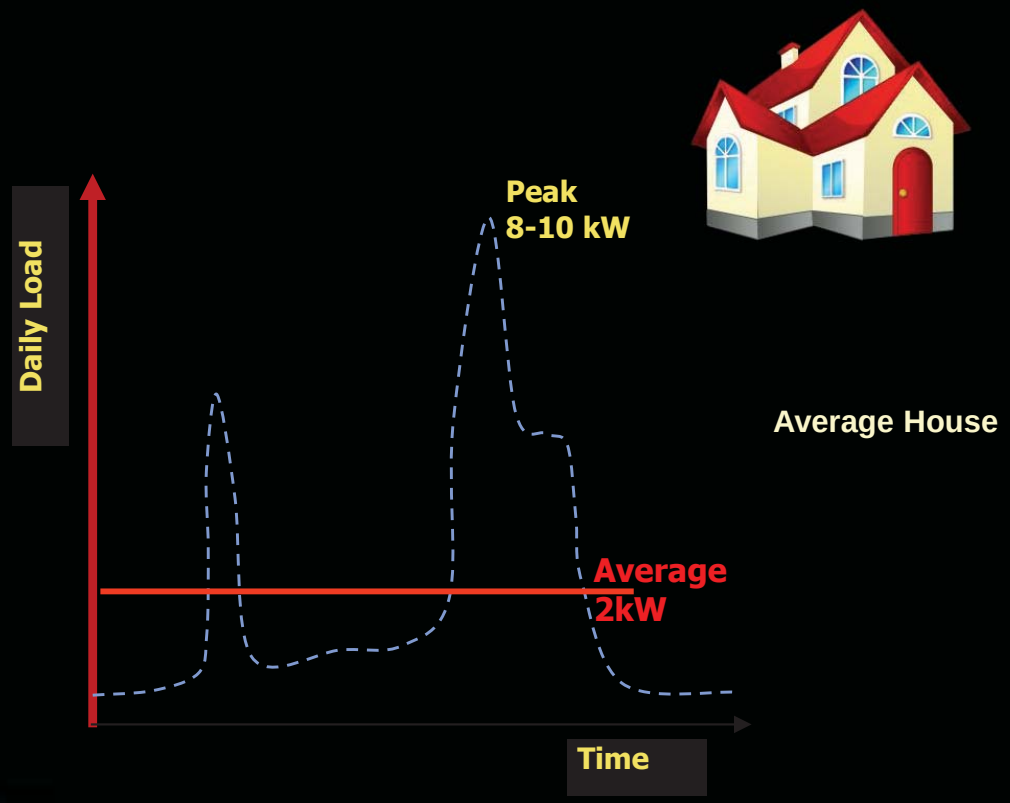
Smart Grid Vision



Advanced Power Grid Needs

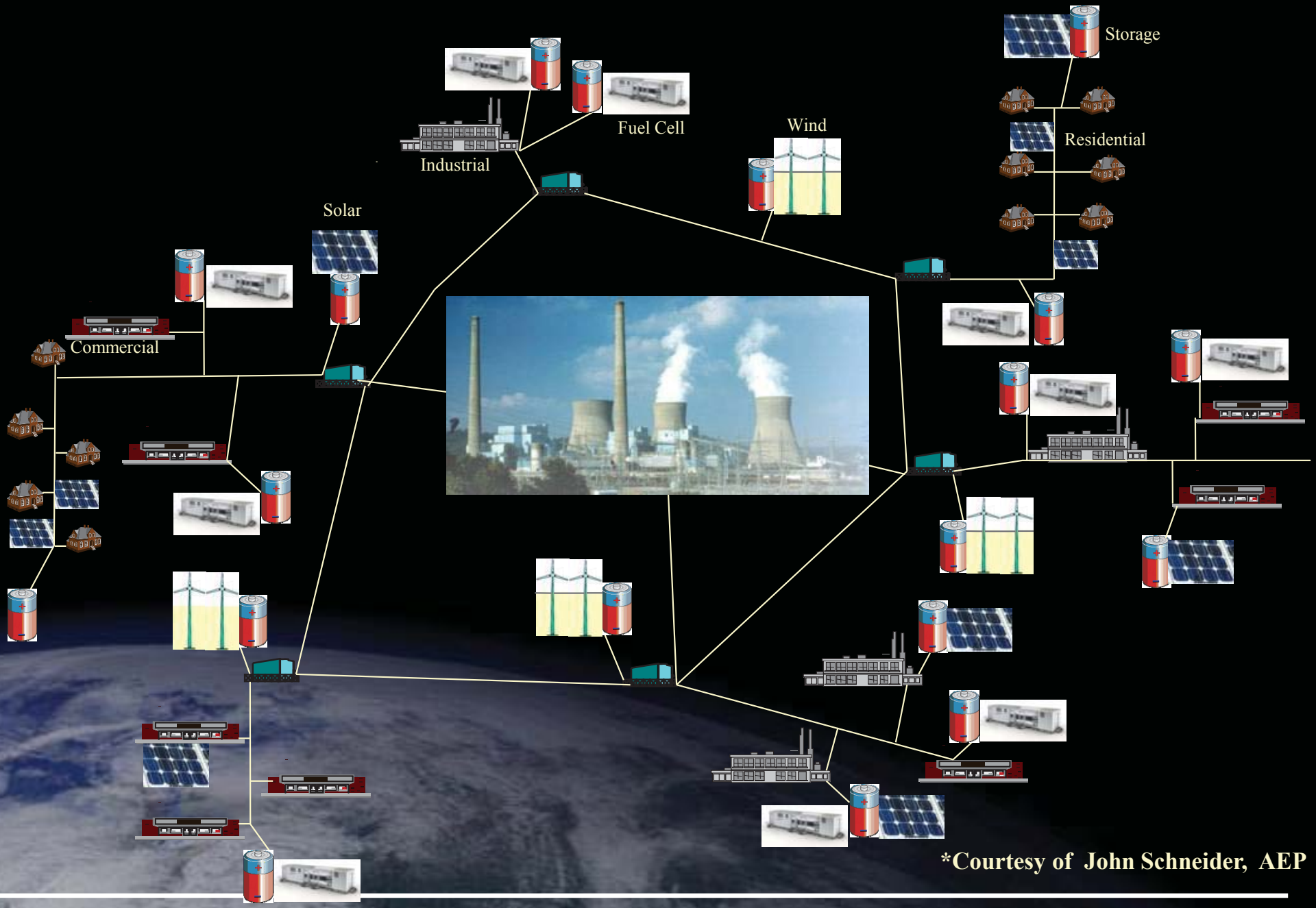
Key Needs:

- **Accommodate the increase in user power requirements**
- **Meet peak power requirements from generation to load at all times**
- **Improve grid security and sustainability**
- **Reduce the impact on the transmission infrastructure**



Solution: Introduce distributed generation & storage to enable base load operation of grid assets

…the Grid of the Future?*



*Courtesy of John Schneider, AEP

Community Micro-grid*

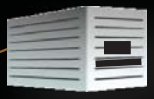
Utility-scale Energy Storage

Rooftop PV Solar

Many new things to manage!

Switches & Power Electronics

Microturbine



Energy Storage

Ground PV Solar Array

PHEVs

Home Energy System

Distributed Generation

* Courtesy of NETL

What is NASA's Interest In Smart Grid?

Technology for NASA mission requirements

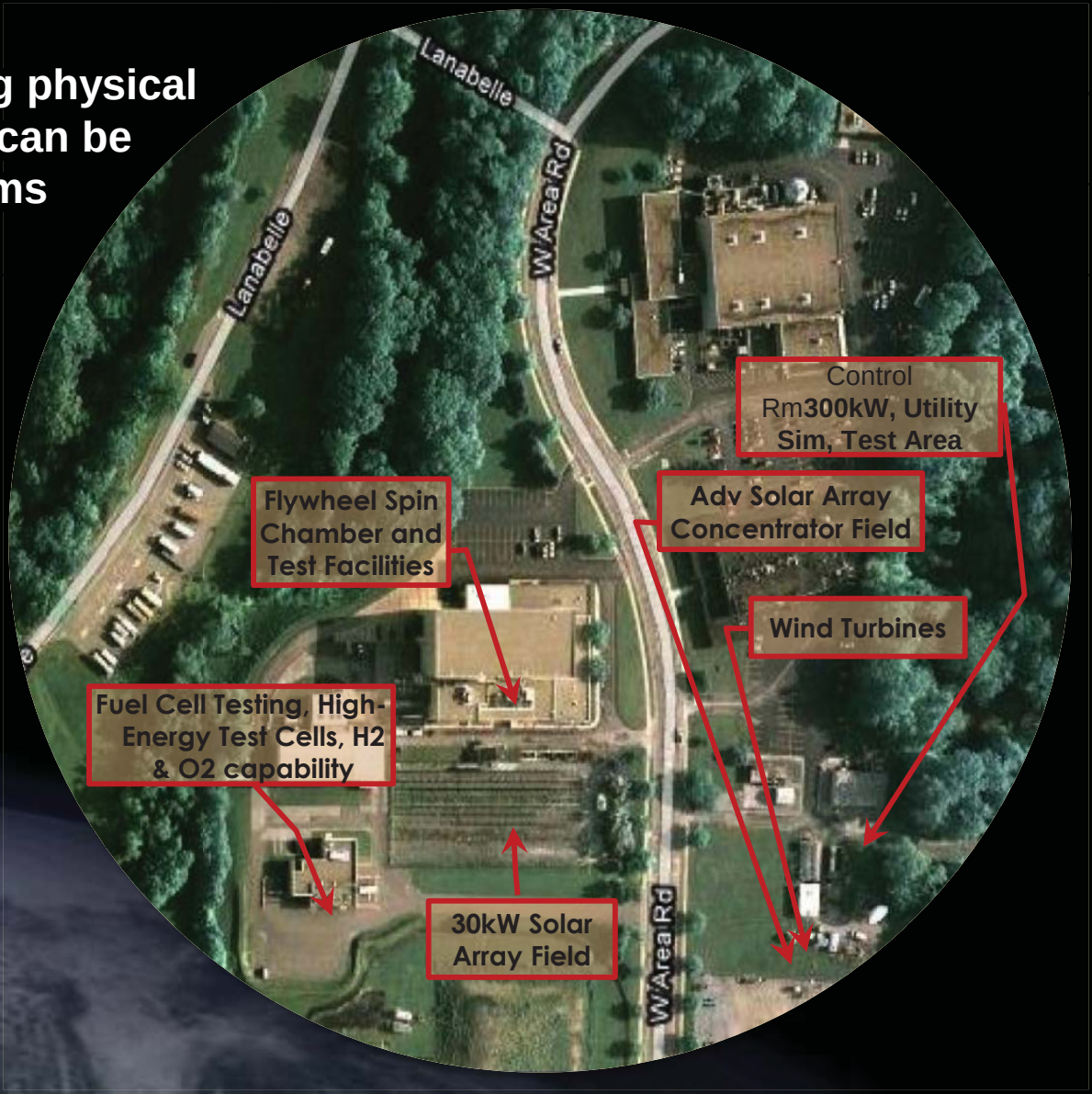
Technology synergy

Technology for U.S. smart grid

NASA and the smart grid both need autonomous controls.
When we solve one problem, we solve both problems

Glenn's Existing Infrastructure

Glenn Research Center has the existing physical assets, and engineering expertise that can be leveraged to solve many of the problems facing the development of micro-grids as well as enhancing facility sustainability



Smart Grid Systems Technology Development

Technology Development Needs

- Systems Technology
  - Routine operation with a high percentage of energy storage
    - Demonstrate real and reactive power control using energy storage
    - Distributed vs centralized energy storage for renewables
  - Understand the benefits of DC vs AC interconnections for sources and storage
- Simulation Technology
  - Load flow / dynamic models for technology development and operation
  - Analytical models of micro-grids that can be replicated and run in real time and faster than real-time
  - Hardware in the loop operation with analytical models

Technology Development Needs

- Automation and Controls
  - Autonomous Controls
    - Economic negotiation of load demand
    - Management of distributed energy resources
    - Power network management
    - Fault detection and recovery
    - Coordination with the larger power grid
  - Adaptive control algorithms for changes in plant and input parameters
  - Prognostics to identify faulty sources and loads
- Intelligent Distribution / Interface Hardware
  - Power Electronics for bi-directional power flow techniques for real and reactive power
  - Bi-directional fault control
  - Intelligent switching centers to enable distributed hierarchical control

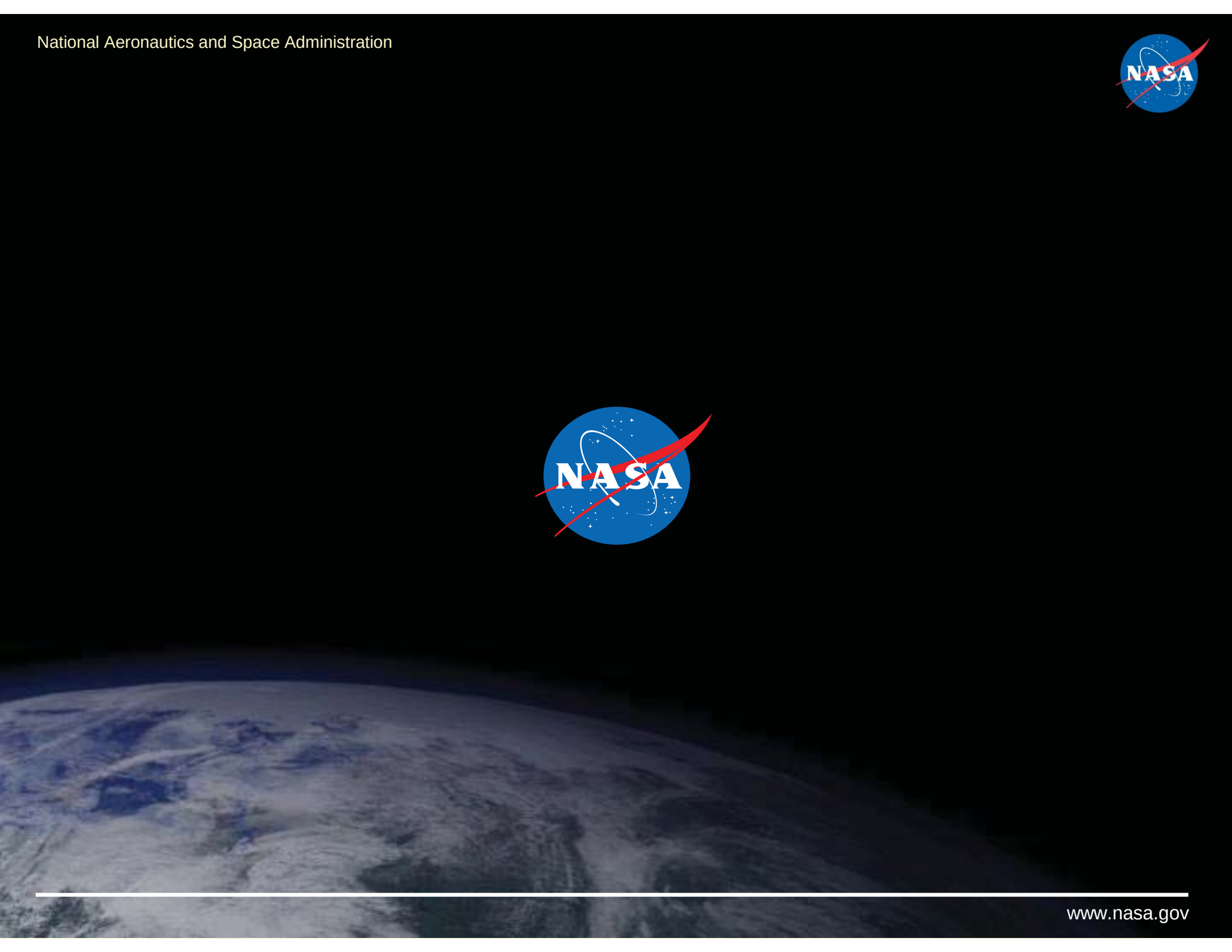
Technology Development Needs

- Communication
  - Wireless data transmission
  - Secure data interchange
- Decision support tools
  - Data Fusion
  - Autonomous and human-agent operations in high information density environments for advanced data integration and presentation
- Sensors
  - Intelligent Sensors with integrated data transmission and energy harvesting
- Intelligent Interface Standards – Data
- Intelligent Interface Standards – Power

Wrap-up

- The key to Smart Grid implementation is successful system integration of the new underlying component and control technologies
  - Integration of "Micro-Grids" or "Micro Energy Islands" with large power grids
  - Incorporation of a high degree of automation and fault tolerance for reliable / secure operation
  - Stable and reliable operation issues with power grids having a high percentage of renewable generation and energy storage
  - Ability to utilize large amounts of data to optimize grid operation

National Aeronautics and Space Administration



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Terrestrial Micro Grids

Islanded micro-grids have very similar needs to space vehicle power systems

- **Both need to function autonomously for extended periods of time**
- **Both need to manage distributed energy resources**
- **Both need to manage loads over constrained capacity and time horizons**
- **Both need to guarantee that the network is safely managed**
- **Both need to detect, isolate, reconfigure and accommodate faults**